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Duane Arnold Energy Center

# CEDAR RIVER OPERATIONAL ECOLOGICAL STUDY ANNUAL REPORT

January 1997 – December 1997


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## INTRODUCTION

This report presents the results of the physical, chemical, and biological studies of the Cedar River in the vicinity of the Duane Arnold Energy Center during the 24nd year of station operation (January 1997 to December 1997).

The Duane Arnold Energy Center Operational Study was implemented in mid-January, 1974. Prior to plant start-up extensive preoperational data were collected from April, 1971 to January, 1974. These preoperational studies provided a substantial amount of "baseline" data with which to compare the information collected since the station became operational. The availability of the 24 years of operational data, collected under a variety of climatic and hydrological conditions, provides an excellent basis for the assessment of the effects of the operation of the Duane Arnold Energy Center on the limnology and water quality of the Cedar River. Equally important is the availability of sufficient data to identify long-term trends in the water quality of the Cedar River which are unrelated to station operation, but are indicative of climatic patterns, changes in land use practices, or pollution control procedures within the Cedar River basin.

## SITE DESCRIPTION

The Duane Arnold Energy Center, a nuclear fueled electrical generating plant, operated by the I.E.S. Utilities, Inc. (formally Iowa Electric Light and Power Company), is located on the west side of the Cedar River, approximately two and one-half miles north-northeast of Palo, Iowa, in Linn County. The plant employs a boiling water nuclear power reactor which produces approximately 560 MWe of power (1658 MWth) at full capacity. Waste heat rejected from the turbine cycle to the condenser circulating water is removed by two closed loop induced draft cooling towers which required a maximum of 11,000 gpm (ca. 24.5 cfs) of water from the Cedar River. A maximum of 7,000 gpm (ca. 15.5 cfs) may be lost through evaporation, while 4,000 gpm (ca. 9 cfs) may be returned to the river as blowdown water from the cool side of the cooling towers.

## OBJECTIVES

Studies to determine the baseline physical, chemical, and biological characteristics of the Cedar River near the Duane Arnold Energy Center prior to plant start-up were instituted in April of 1971. These preoperational studies are described in earlier reports.[1-3] Data from these studies served as a basis for the development of the operational study.

The operational studies were designed to identify and evaluate any significant effects of chemical or thermal discharges from the generating station into the Cedar River, as well as to assess the magnitude of impingement of the fishery on intake screens. These were first implemented in January, 1974 and have continued without interruption through the current year.[4-26]

The specific objectives of the operational study are twofold:

1. To continue routine water quality determinations in the Cedar River in order to identify any conditions which could result in environmental or water quality problems.
2. To conduct physical, chemical, and biological studies in and downstream of the discharge canal and to compare the results with similar studies executed above the intake. This will make possible the determination of any water quality changes occurring as a result of chemical additions or condenser passage, and to identify any impacts of the plant effluent on aquatic communities downstream of the discharge.

## STUDY PLAN

During the operational phase of the study sampling sites were established in the discharge canal and at four locations in the Cedar River (Figure 1): 1) upstream of the plant at the Lewis Access Bridge (Station 1); 2) directly upstream of the plant intake (Station 2); 3) at a point within the mixing zone approximately 140 feet downstream of the plant discharge (Station 3); and 4) adjacent to Comp Farm, located about one-half mile below the plant (Station 4). Samples were also taken from the discharge canal (Station 5).

Prior to 1979, samples were collected and analyzed by the Department of Environmental Engineering of the University of Iowa. From January, 1979 through December, 1983 samples were collected an analyzed by Ecological Analysts, Inc. Since 1984 collection and analysis of samples has been conducted by the University of Iowa Hygienic Laboratory, located in Iowa City, Iowa. The conclusions contained in this annual report are based on the results of their analyses. Samples for routine physical, chemical, and biological analysis were taken twice per month, while other studies were conducted seasonally. The following are discussed in this report:

I. General Water Quality Analysis

- A. Frequency: twice per month
- B. Location: at all five stations
- C. Parameters Measured:
  1. Temperature
  2. Turbidity
  3. Solids (total, dissolved, and suspended)
  4. Dissolved oxygen
  5. Carbon dioxide
  6. Alkalinity (total and carbonate)
  7. pH
  8. Hardness series (total and calcium)
  9. Phosphate series (total and ortho)
  10. Ammonia
  11. Nitrate
  12. Iron
  13. Biochemical oxygen demand
  14. Coliform series (fecal and *E. coli*)

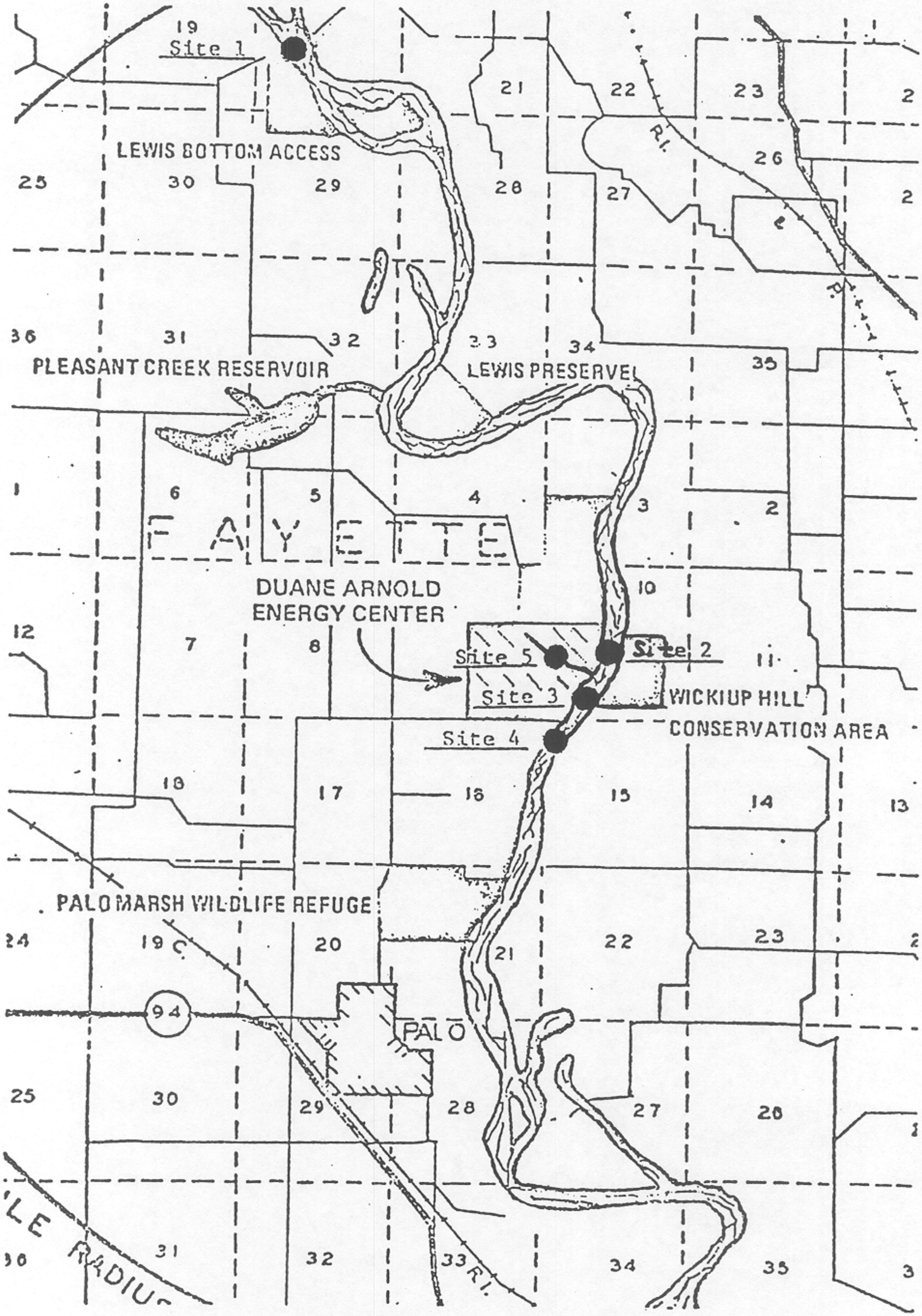


Figure 1. Location of Operational Sampling Sites

II. Additional Chemical Determinations

A. Frequency: twice yearly (April and August)

B. Locations: at all five stations

C. Parameters Measured:

1. Chromium
2. Copper
3. Lead
4. Manganese
5. Mercury
6. Zinc
7. Chloride
8. Sulfate

III. Biological Studies

A. Benthic Studies:

1. Frequency: April and August
2. Location: at all five stations

B. Impingement Studies:

1. Frequency: daily
2. Location: intake structure

C. Asiatic Clam (Corbicula) and Zebra Mussel (Dreissena) Surveys:

1. Frequency: twice yearly (May and September)
2. Location: upstream and downstream of the plant, intake bay, cooling tower basin, and discharge canal. The Zebra mussel survey also included Pleasant Creek Reservoir.

## OBSERVATIONS

### Physical Conditions

Hydrology (Table 1)

River flows during 1997 were higher than those present in 1996. Estimated mean flow for 1997 was 4,996 cfs, only slightly less than the average flow of 5,228 cfs observed during the 26 years of the Cedar River water quality study. Mean monthly discharge at the U.S. Geological Survey gauging station in Cedar Rapids ranged from 1,701 cfs in December to 12,150 cfs in March. Flows were in excess of the 1961-1990 monthly median discharges from January through October. The lowest daily river flow, 1,050 cfs occurred on December 31 while a maximum daily river discharge of 23,000 cfs occurred on March 17.

River flows remained relatively stable from January to mid-February ranging from 1,830 to 5,070 cfs and then increased to over 12,000 cfs by February 23. Flows declined in late February but increased sharply in March reaching a yearly high of 23,000 cfs by March 17 and remained in excess of 11,000 cfs through early April. River discharge declined steadily through the remainder of the month to less than 5,000 cfs by April 28. Flows again increased, exceeding 10,000 cfs in early May and then declined ranging from ca. 4,000 to 7,000 cfs from mid-May through mid-June. A peak summer discharge of 10,500 cfs occurred on June 26. Discharge generally declined from late July through September ranging from ca. 2,400 to 6,000 cfs. Flows continued to generally declined during the fall and winter months with lowest levels of less than 1,500 cfs occurring in late December. Hydrological data are summarized in Table 1.

<u>Temperature</u> (Table 2)

In 1997, ambient upstream river temperatures at Station 2 ranged from 0.0°C (32.0°F) from January through early March to 28.0°C (82.4°F) in mid-July. The maximum temperature observed was 2°C (3.6°F) higher than the maximum present in 1996[26] and 1.4°C (2.5°F) higher than the 1980-1995 average maximum of 26.6°C (74.9°F). A maximum downstream temperature of 28°C (82.4°F) was also observed at Station 3 on July 16. The highest discharge canal temperature observed during the 1997 study was 31.0°C (87.8°F) on both July 1 and 16.

Station operation continued to have a negligible effect on downstream water temperatures. A maximum temperature differential ($\Delta T$) between upstream temperatures at Station 2 and downstream at Station 3, located in the mixing zone for the discharge canal, of 1°C (1.8°F) was measured on October 2. The maximum $\Delta T$ between the Comp Farm location (Station 4) one-half mile below the plant and the upstream location (Station 2) was 1.5°C (2.7°F) on September 17. A maximum temperature differential between the ambient river and the discharge canal (Station

5) observed during the 1997 study of 13.0°C (23.4°F) occurred on February 5. In most cases however, discharge canal temperatures were less than 5°C (9°F) higher than ambient river values. Obviously there were no observed instances in which downstream river temperatures exceeded upstream river temperatures by more than the Iowa Water Quality standard of 3°C[27]. A summary of water temperature differentials between upstream and downstream locations is given in Table 3.

Turbidity (Table 4)

Average river turbidity values during 1997 were slightly higher than those present since 1993 (Table 27). Peak values of 130 to 140 NTU occurred on February 19. Low values of 4 to 5 NTU occurred from mid-November through December during a period of low stable river flow.

Turbidity values in the discharge canal were generally similar or only slightly higher than river values but, on occasion, high values of 120 to 220 NTU were observed. A maximum value of 700 NTU, observed in the discharge canal on December 3, was apparently the result of localized runoff not related to station operation.

Solids (Table 5-7)

Solids determination included total, dissolved and suspended. Total solids values in upstream river samples in 1997 ranged from 460 to 490 mg/L in May, July and October to 230 mg/L in March during a period of extremely high river flow. Most total solids values were between 300 and 400 mg/L.

Dissolved solids values in the upstream river ranged from 140 mg/L in February to 360 mg/L in November. As expected, high values occurred during periods of low flow in November and December and low values during periods of snowmelt and runoff in February and March. Dissolved solids in the discharge canal were usually much higher than in the river, ranging from 110 mg/L on a single instance in February to 2,020 mg/L in July. Dissolved solids values in the discharge canal were consistently in excess of 1,000 mg/L from mid-April through November. As in most previous years, dissolved solids values at downstream locations were slightly higher than levels observed upstream ranging from 170 to 420 mg/L.

Low suspended solids of 4 to 12 mg/L occurred in early February, November and December. High values, 240 to 280 mg/L, occurred in late February during a period of increasing runoff. Suspended solids values in the discharge canal exhibited considerable variation. Low values of 4 to 7 mg/L were present in February while high values of 230 to 350 mg/L occurred from May through July. A maximum value of 450 mg/L, reported in early December appeared to be the result of localized runoff.

## Chemical Conditions

Dissolved Oxygen (Table 8)

Dissolved oxygen concentrations in river samples collected in 1997 ranged from 7.5 to 19.8 mg/L (93 to 139% saturation). Dissolved oxygen concentrations of 10.6 to 13.5 mg/L were consistently present from January through early June. Concentrations generally declined from mid-June through early September and then increased ranging from 10.4 to 19.8 mg/L for the remainder of the year. Lowest concentrations were observed in early July while the highest values occurred in mid-November. Supersaturated dissolved oxygen concentrations associated with algal photosynthesis were frequently present from late summer through late fall.

Dissolved oxygen concentrations in the discharge canal (Station 5) were generally only slightly lower than river levels. Discharge canal concentrations ranged from 6.1 mg/L (87% saturation) in late August to 14.5 mg/L (105% saturation) in mid-March. Differences in dissolved oxygen concentrations at upstream and downstream locations were minimal and station operation appeared to have no significant impact on dissolved oxygen concentrations below the plant.

Carbon Dioxide (Table 9)

With the exception of the winter and early spring periods, carbon dioxide concentrations were low throughout 1997. Maximum values of 9 to 18 mg/L were present from January through early March but never exceeded 5 mg/L for the remainder of the year. Minimum values of 1 mg/L or less commonly occurred from mid-June through December. Concentrations in the discharge canal could not be precisely determined but, based on pH values, were probably higher than river levels.

Alkalinity, pH, Hardness (Tables 10-14)

These interrelated parameters are influenced by a variety of factors including hydrological, climatic and biological conditions.

Total alkalinity values in the 1997 river samples ranged from 94 mg/L in early February at the beginning of a period of snowmelt and runoff to 240 mg/L in January. Values of less than 150 mg/L were also observed during periods of high flow in March and also in August, September and early October. Total alkalinity values in the discharge canal exhibited considerable fluctuation ranging form 44 to 316 mg/L.

Carbonate alkalinity was not present in river samples from January through May. Highest carbonate levels, 10 to 13 mg/L, occurred in October and November. Carbonate alkalinity was never observed in the discharge canal.

Values for pH in river samples ranged from 7.4 to 9.0. Values of less than 8 units were consistently present in river samples from January through March. Highest values, 8.5 to 9.0 units, usually accompanied algal blooms from mid-July through December. Due to the addition of buffering agents, pH values in the discharge canal exhibited less variations, ranging from 7.4 to 8.3.

Total hardness values in the 1997 upstream river samples were slightly lower than those of the last several years (Table 27) and exhibited a pattern similar to that observed for total alkalinity. Lowest values 120 to 160 mg/L occurred at intervals in January, February and March while highest levels, 320 to 380 mg/L were present in late January and December. Calcium hardness values paralleled total hardness values. Low values of 80 to 84 mg/L occurred in mid-February. High values of 240 mg/L occurred in December.

Hardness values in the discharge canal continued to be consistently higher than levels present in the river; a result of reconcentrations in the blow down from the towers. Total hardness values in the discharge canal ranged from 110 to 1,300 mg/L. As a result of high hardness values in the discharge canal, downstream levels were usually slightly higher than those present upstream.

<u>Phosphates</u> (Table 15 and 16)

Phosphate concentrations in the 1997 samples were similar to those present in 1996 (Table 27). Total phosphate concentrations ranged from 0.1 mg/L in September and November to 1.1 mg/L in mid-February. Levels in the discharge canal were consistently higher than river levels ranging from 0.3 to 2.3 mg/L but the effect on downstream concentrations was minimal.

Orthophosphate concentrations in the 1997 river samples ranged from 0.6 mg/L in mid-February to <0.1 mg/L in most of May to early October samples. Lowest orthophosphate concentrations frequently occurred in conjunction with algal blooms due to the uptake of phosphate by algal cells. Orthophosphate concentrations in the discharge canal ranged from 0.1 to 1.5 mg/L.

<u>Ammonia</u> (Table 17)

Ammonia concentrations in the 1997 river samples exhibited a pattern similar to that present in 1996[26]. Maximum concentrations, 0.5 to 1.0 mg/L (as N) occurred from January through early March. Values of less than 0.1 mg/L (as N) were consistently present from April through December. Ammonia concentrations in the discharge were generally slightly higher, ranging from <0.1 to 1.5 mg/L (as N).

<u>Nitrate</u> (Table 18)

Average nitrate concentrations in river samples increased slightly over 1996 but were still well below levels observed form 1990 to 1993 (Table 26). Low values of 1.1 to 1.4 mg/L (as N) were present in September. A maximum nitrate concentrations of 10 mg/L (as N) was present at all locations on May 5.

Nitrate concentrations in the discharge canal were usually higher than river levels. A maximum nitrate concentration of 25 mg/L (as N) was observed in the discharge canal on July 16.

Iron (Table 19)

Iron concentrations in the 1997 river samples continued to be high, exceeding the high levels present in 1996[26]. Concentrations ranged from 0.18 mg/L in November and December to 9.0 mg/L in mid-February. As in previous years, high iron concentrations frequently accompanied increased turbidity and suspended solids levels indicating that most of the iron was in suspended form rather than in solution. Overall, iron levels in the discharge canal were slightly higher than river levels but iron concentrations downstream were unaffected.

## Biological Studies

Biochemical Oxygen Demand (Table 20)

Five day biochemical oxygen demand ($BOD_5$) values in the 1997 river samples were slightly lower than those observed in 1996 when the highest BOD values present since 1989 were present[26]. However, 1997 values were similar to or slightly higher than those present since 1989 (Table 26). Maximum BOD levels (19 to 21 mg/L) occurred in mid-February in conjunction with snowmelt and runoff. Values of 11 to 13 mg/L were observed on occasions in the summer and early fall in conjuction with algal blooms. Low values of 1 mg/L or less were present in November and December. BOD levels in the discharge canal were generally similar to those present at river locations.

Coliform Organisms (Tables 21 and 22)

Coliform determinations included enumeration of fecal coliforms as well as specific determination of Escherichia coli.

Maximum river concentrations of fecal coliform and E. coli of 4,200 and 5,100 organisms/100 ml respectively were observed at the Lewis Access location (Station 1) on September 3. Due likely to localized runoff since downstream levels were lower. Both fecal coliform and E. coli concentrations exhibited wide fluctuations during the year but in general lowest values, <10 to 40 organisms/100 ml, were present at intervals in the summer and late fall.

Extremely high fecal coliform and E. coli concentrations of 55,000 and 78,000 organisms/100 ml respectively were observed in the discharge canal on December 3. It appeared that these high levels resulted from localized land runoff into a small ditch, flowing into the discharge canal, following a light rain and were unrelated to station operation. Although high coliform concentrations were presently sporadically in the discharge canal the effect on the downstream river was always minimal.

## ADDITIONAL STUDIES

In addition to the routine twice monthly studies, a number of seasonal limnological and water quality investigation were conducted in 1997. The studies discussed here include additional chemical determinations, benthic surveys, Asiatic clam (Corbicula) and zebra mussel (Dreissena) surveys and impingement surveys.

### Additional Chemical Determinations

Samples for additional chemical determinations were collected on April 16 and August 6, 1997 from all river locations and in the discharge canal and analyzed for chloride, sulfate, chromium, copper, lead, maganese, mercury and zinc. Concentrations of all parameters fell within the expected ranges.

Chloride and sulfate concentrations were similar at all river locations on both sampling dates and also similar to values observed in 1995 and 1996[25,26]. In 1997, chloride concentrations in river samples ranged from 19 to 27 mg/l. Sulfate concentrations ranged from 35 to 44 mg/L.

Levels of the heavy metals chromium, copper, lead, mercury and zinc were below detection limits in the river samples. Manganese values in the river samples were slightly lower than those observed in 1996, ranging from 80 to 110 ug/L.

Reconcentration of solids in the blowdown from the cooling towers resulted in increased levels of chlorides, sulfates, manganese and zinc in both the April and August 1997 samples from the discharge canal but in most cases downstream increases were negligible. The high sulfate concentrations present in the discharge canal on both samples dates, 570 and 920 mg/L, were due primarily to the addition of sulfuric acid for pH control in the cooling water. Sulfate concentrations exhibited only slight increases at downstream locations on both sampling dates increasing from 35 mg/L upstream of the station to 41 mg/L downstream in April and from 37 mg/L upstream to 44 mg/L downstream in August. The results of additional chemical determinations are presented in Table 23.

## Benthic Studies

Artificial substrate samplers (Hester-Dendy) were placed at each of the four sampling locations, upstream and downstream of the discharge canal and in the discharge canal on July 1 and September 3, 1997. These substrates were collected on August 11 and October 16, 1997 following a six week period to allow for the development of a benthic community.

As in past studies, the benthic communities which developed on the substrates were much larger and more diverse than those found in the shifting sand and silt bottom characteristic of the Cedar River in the vicinity of the Duane Arnold Energy Center. Ponar grab samples taken from the five sites rarely contained any benthic organisms, but a diverse assemblage of organisms developed on the substrates during the six week colonization period.

A total of 40 taxa were identified during the two sampling periods, 26 in August and 32 in October. These included 34 species (6 orders) of insects, two annelids, one snail, one crustacean and one flatworm. Caddis fly larvae (Trichoptera) were the dominant organisms in both the July and October river samples.

Both the total numbers and diversity of organisms in the discharge canal continued to be far lower than in the river samples. A total of 9 taxa; one in August and eight in October were present. A total of 260 organisms, 49 in August and 211 in October were present in the discharge canal samples.

In general, there was little difference in the composition of benthic populations between upstream and downstream location in the August samples although total numbers were lower at the downstream location. No substrate was recovered from the Lewis Access site (Station 1) in October but the composition of benthic organisms at the remaining upstream site was similar to that at the downstream locations. The major differences between the numbers of organisms at the various sites appeared to be due to smaller numbers of the caddis fly larvae Hydropsyche bidens, especially directly downstream of the discharge (Station 3).

As in prior years the artificial substrate studies indicate that the Cedar River, both upstream and downstream of the Duane Arnold Energy Center is capable of supporting a relatively diverse benthic macroinvertebrate fauna in those limited areas where a suitable substrate is available. The discharge canal however, is not a suitable habitat for most benthic organisms. The results of the benthic studies are presented in Table 24.

**Asiatic Clam and Zebra Mussel Surveys**

In past years a number of power generation facilities experienced problems with blockage of cooling water intake systems by large numbers of Asiatic clams (Corbicula sp.). Although this clam commonly occurs in portions of the Iowa reach of the Mississippi River, it is normally absent from areas with shifting sand/silt substrates such as occur in the Cedar River in the vicinity of the Duane Arnold Energy center. Corbicula has not been collected from the Cedar River in the vicinity of the DAEC during the routine monitoring program, which was implemented in April of 1971. A single Corbicula was, however, collected in January of 1979 in the vicinity of Lewis Access, upstream of DAEC, by Hazelton personnel. Because Corbicula has been reported on one occasion from the Cedar River and is commonly found in power plant intakes on the Mississippi River, studies were implemented at the Duane Arnold Energy Center in 1981 to determine if the organism was present in the vicinity of the station or had established itself within the system. No Corbicula were collected during the 1981 to 1996 investigation[11-26].

The zebra mussel (Dreissena polymorpha) is a European form which was first found in the United States in Lakes St. Clair and Erie in 1988. The zebra mussel has been a major problem at many power plant intakes as well as a number of municipal water treatment plants in the United States. The organisms tend to grow in clumps attached to a solid substrate and can rapidly clog intake structures, screens, and pipes. It is difficult to control chemically and frequently must be removed mechanically. The mussel is adapted to both river and lake habitats and does especially well in enriched waters which support large plankton populations that it utilizes as food. Unlike the Asiatic clam (Corbicula), it is capable of living in cold waters and does not require a silty substrate.

Since its introduction into the United States the zebra mussel has rapidly expanded its range. It is now found in all of the Great Lakes. In 1991, just three years after they were first found in the U.S., they were collected in the Hudson, Illinois, Mississippi, Ohio, Susquehanna, Tennessee, and Cumberland Rivers[28]. The U.S. Army Corps of Engineers reports that zebra mussel populations have increases exponentially on lock and dam surfaces since their introduction into the Mississippi River in 1991[29,30] and the organism has also established itself at several locations in the Iowa reach of the Mississippi River. Zebra mussel populations increased rapidly in the Iowa reach of the Mississippi River in 1994 and 1995 but populations appear to have remained relatively constant in 1996 and 1997.

Studies were conducted from May through October 1997 in the Pleasant Creek Reservoir and Cedar River in the vicinity of the Duane Arnold Energy Center by Dr. J.K. Johnson, Iowa Institute of Hydraulic Research. Dr. Johnson did not observe any veliger (larual) or adult zebra mussels in the course of his investigations[31].

Additional studies were also conducted by the University of Iowa Hygienic Laboratory in May and September 1997 to determine if either Asiatic clams or zebra mussels were present in the vicinity of the Duane Arnold Energy Center. Sampling was carried out upstream and downstream of the station, in the intake bay, the cooling tower basin and discharge canal as well as in the Pleasant Creek Reservoir utilizing a mussel rake and Ponar sampler, as well as visual inspections of appropriate substrates. No Asiatic Clams or zebra mussels were found at any of the sites of during the 1997 investigations.

## Impingement Studies

The total number of fish impinged on the intake screens at the Duane Arnold Energy Center during 1997 as reported by IES Utilities personnel, was lower than during 1996[26]. Daily counts indicated a total of 533 fish were impinged during 1997. Highest impingement occurred during the late fall to early spring period. During the months of January to March and in November and December 421 fish, or approximately 79% of the yearly impingement total, were removed from the trash baskets. Lowest impingement rates occurred in August when only 3 fish were removed from the trash baskets. The month with the highest impingement rate was February when 130 fish were collected in the trash baskets. The results of the daily trash basket counts are given in Table 25.

# DISCUSSION AND CONCLUSIONS

During the 23 year period that the Duane Arnold Energy Center has been operational, its impact on the water quality of the Cedar River has been minimal. As in the past the major factors influencing the water quality of the Cedar River in 1997 continued to be climatic and hydrological conditions and agricultural activities within the Cedar River basin.

During 1997 the mean discharge in the Cedar River was 4,996 cfs, similar to the 1972 to 1997 mean flow of 5,228 cfs but well above the 3,200 cfs mean flow present in 1996. Average discharge from the cooling tower into the river is only ca. 9 cfs and, as expected, station operation had a negligible impact on downstream water temperatures. In 1997 the maximum observed temperature differential ($\Delta T$) between ambient upstream temperatures (Station 2) and temperatures in the mixing zone, ca. 140 feet downstream of the discharge (Station 3), was only 1.0°C (1.8°F). A maximum $\Delta T$ value between Station 2 and Station 4, one-half mile downstream of the station, was 1.5°C (2.7°F). In both cases these maximum differentials occurred in the fall when ambient river temperatures were relatively low, 16.5°C to 21.5°C (62°F to 71°F). When average temperatures for the 1997 study periods are compared, the average temperature differential between Station 2 and Station 4 was only 0.3°C (0.5°F) (Table 26).

Station operation continued to have only a minimal effect on other water quality parameters. Several parameters exhibited slight increases in downstream concentrations but in all cases these increases were not sufficiently high to adversely impact aquatic life or violate applicable water quality standards[27]. Parameters exhibiting downstream increases were dissolved solids which increased from an average of 283 mg/L at Station 2 to 308 mg/L at Station 4, total hardness which increased from 249 to 270 mg/L, total phosphate which increased from 0.30 to 0.31 mg/L and nitrate which increased from 5.0 to 5.2 mg/L (as N) (Table 26). These findings are comparable to those observed in prior years.

Additional chemical determinations conducted in April and August 1997 indicated that heavy metal concentrations where not affected by station operation (Table 23). With the exception of manganese, heavy metal concentrations in both river and discharge canal samples were below detection limits on both sampling dates. Only sulfates, which are added to the cooling towers in the form of sulphuric acid for pH control, exhibited slight increases at downstream locations. In no instance however were heavy metal or sulfate concentrations in any of the river samples in excess of the Iowa Water Quality standards[27].

In 1996 fecal coliform concentrations at downstream locations exceeded upstream values by more than 200 organisms/100 ml on two occasions but this condition was not observed during the 1997 studies. Extremely high coliform concentrations were observed in the discharge canal on several occasions in 1997. It appeared that these high levels resulted from localized runoff into a small ditch flowing into the discharge canal rather than station operation. In no case were downstream concentrations substantially increased.

In general the water quality of the Cedar River during the 1997 studies was similar to that observed in prior years when similar climatic and hydrological conditions were present and it appears that agricultural activities continue to exert a major effect on the limnology of the river.

High nitrate concentrations have been observed in the Cedar River at intervals since the mid 1970's peaking at a mean value of 8.6 mg/L (as N) in 1983, a year of high river discharge. In general highest nitrate values occurred during high river flows while low values occurred during abnormally low flow years such as 1989 when mean river flow was only 947 cfs and mean nitrate concentration fell to 1.5 mg/L (as N). Nitrate concentrations declined following 1993 when the extremely heavy rainfall flushed much of the nitrate from the basin. Mean yearly nitrate levels have remained below 5.5 mg/L (as N) since that time (Table 27). Relative loading value for nitrate, obtained by multiplying average annual nitrate concentration by cumulative runoff, was higher in 1997 than 1996 but similar to those observed in 1994 and 1995 (Table 28).

Snow melt and subsequent runoff from agricultural land in the basin was also the likely cause of the high BOD values (19 to 21 mg/L) observed in the river in mid-February. High BOD values (11 to 13 mg/L) were also observed in August and September as the result of the death and decay of large algal populations. These high BOD values are also related to agricultural activities since the high levels of nitrogen and phosphorus entering the river from agricultural land supported extensive algal growth in the river. As expected these large algal populations contributed to the high pH levels and supersaturated dissolved concentrations observed during that time.

The numbers of fish impinged on the intake screens at the Duane Arnold Energy Center during 1997 was lower than during 1996. During the current year a total of 533 fish were impinged as compared to 897 in 1996. As in past years, highest impingement rates occurred during the late fall through early spring period. These numbers continued to be extremely low considering the size and composition of the fish population present in the river and the impact of impingement on the fishery of the Cedar River is insignificant.

Populations of benthic (bottom dwelling) organisms which colonized artificial substrates in the summer and fall of 1997 were similar to those present in past years. Diversity was similar at upstream and downstream river locations and indicated that where adequate substrate is available the Cedar River is capable of supporting a diverse benthic biota. The paucity of organism normally present in the Cedar River in the vicinity of the Duane Arnold Energy Center is due to the shifting sand bottom which does not provide a suitable substrate for bottom dwelling organisms.

The size and diversity of benthic populations developing on substrates placed in the discharge canal were, as in past studies, far smaller than those developing on the river substrates. Obviously the discharge canal does not provide a suitable habitat for most benthic organisms.

Since 1981 studies have been conducted to determine if the Asiatic Clam is present in the vicinity of the Duane Arnold Energy Center. Studies to determine if the zebra mussel is present have been conducted since 1991 and neither form has been found. Although zebra mussels are present in the Iowa reach of the Mississippi River, populations appear to have remained relatively stable in 1996 and 1997 but the possibility that the mussel could become established in the Cedar River should not be discounted.

Table 1

Summary of Hydrological Conditions
Cedar River at Cedar Rapids*
1997

| Date | Mean Monthly Discharge cfs | Percent of Median Discharge† |
|---|---|---|
| January | 3,483 | 278 |
| February | 4,501 | 275 |
| March | 12,150 | 200 |
| April | 7,343 | 109 |
| May | 7,485 | 156 |
| June | 6,126 | 113 |
| July | 5,841 | 137 |
| August | 3,525 | 145 |
| September | 2,741 | 125 |
| October | 3,136 | 127 |
| November | 1,915 | 64 |
| December | 1,701 | 90 |

*Data obtained from U.S. Geological Survey records
†Based on 1961-1990 median flow

Table 2

Temperature (°C) Values for the Cedar River
near the Duane Arnold Energy Center during 1997

| | Sampling Locations | | | | |
|---|---|---|---|---|---|
| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 |
| Jan-22 | 0.0 | 0.0 | 1.5 | 0.0 | 0.0 |
| Feb-05 | 0.0 | 0.0 | 13.0 | 0.0 | 0.0 |
| Feb-19 | 0.0 | 0.0 | 2.0 | 0.5 | 0.5 |
| Mar-06 | 0.0 | 0.0 | 4.0 | 0.5 | 0.5 |
| Mar-17 | 1.0 | 1.0 | 2.0 | 1.5 | 1.0 |
| Apr-02 | 9.5 | 9.0 | 13.5 | 9.0 | 9.5 |
| Apr-16 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| May-05 | 12.5 | 13.0 | 25.5 | 13.0 | 13.0 |
| May-19 | 14.5 | 14.5 | 19.0 | 14.5 | 15.0 |
| Jun-04 | 19.5 | 20.0 | * | 20.0 | 20.5 |
| Jun-17 | 21.5 | 22.0 | 26.0 | 22.0 | 22.5 |
| Jul-01 | 25.5 | 26.0 | 31.0 | 26.0 | 26.0 |
| Jul-16 | 27.0 | 28.0 | 31.0 | 28.0 | 28.0 |
| Aug-06 | 23.0 | 23.0 | 24.5 | 23.0 | 23.0 |
| Aug-20 | 20.5 | 21.5 | 28.0 | 22.0 | 21.5 |
| Sep-03 | 21.0 | 21.0 | 23.5 | 21.0 | 22.0 |
| Sep-17 | 21.0 | 21.5 | 26.5 | 22.0 | 23.0 |
| Oct-02 | 16.0 | 16.5 | 25.5 | 17.5 | 17.5 |
| Oct-16 | 11.0 | 11.0 | 14.5 | 11.5 | 12.0 |
| Nov-03 | 4.5 | 4.5 | 7.0 | 5.0 | 4.5 |
| Nov-19 | 1.0 | 1.0 | 6.0 | 1.0 | 1.5 |
| Dec-03 | 3.0 | 3.0 | 6.5 | 3.5 | 3.5 |
| Dec-17 | 1.0 | 1.0 | 9.0 | 1.0 | 1.5 |

*Not sampled

Table 3

Summary of Water Temperature Differentials and Station Output During Periods of Cedar River Sampling in 1997

| Date 1997 | T (°C) Upstream River (Station 2) vs. Discharge (Station 5) | T (°C) Upstream River (Station 2) vs. Downstream River (Station 3) | T (°C) Upstream River (Station 2) vs. Downstream River (Station 4) | Station Output (% Full Power) |
|---|---|---|---|---|
| Jan-08 | 0.0 | 0.5 | 0.0 | 100 |
| Jan-22 | 1.5 | 0.0 | 0.0 | 100 |
| Feb-05 | 13.0 | 0.0 | 0.0 | 100 |
| Feb-19 | 2.0 | 0.5 | 0.5 | 100 |
| Mar-06 | 4.0 | 0.5 | 0.5 | 100 |
| Mar-17 | 1.0 | 0.5 | 0.0 | 100 |
| Apr-02 | 4.5 | 0.0 | 0.5 | 100 |
| Apr-16 | 0.0 | 0.0 | 0.0 | 100 |
| May-05 | 12.5 | 0.0 | 0.0 | 100 |
| May-19 | 4.5 | 0.0 | 0.5 | 80 |
| Jun-04 | * | 0.0 | 0.5 | 100 |
| Jun-17 | 4.0 | 0.0 | 0.5 | 100 |
| Jul-01 | 5.0 | 0.0 | 0.0 | 100 |
| Jul-16 | 3.0 | 0.0 | 0.0 | 100 |
| Aug-06 | 1.5 | 0.0 | 0.0 | 100 |
| Aug-20 | 6.5 | 0.5 | 0.0 | 100 |
| Sep-03 | 2.5 | 0.0 | 1.0 | 100 |
| Sep-17 | 5.0 | 0.5 | 1.5 | 95 |
| Oct-02 | 9.0 | 1.0 | 1.0 | 100 |
| Oct-16 | 3.5 | 0.5 | 1.0 | 100 |
| Nov-03 | 2.5 | 0.5 | 0.0 | 96 |
| Nov-19 | 5.0 | 0.0 | 0.5 | 100 |
| Dec-03 | 3.5 | 0.5 | 0.5 | 100 |
| Dec-17 | 8.0 | 0.0 | 0.0 | 100 |

*No data

Table 4

Turbidity (NTU) Values for the Cedar River
near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 38 | 36 | 35 | 36 | 36 |
| Jan-22 | 11 | 8 | 28 | 9 | 10 |
| Feb-05 | 10 | 11 | 3 | 10 | 10 |
| Feb-19 | 130 | 130 | 2 | 130 | 140 |
| Mar-06 | 29 | 33 | 16 | 30 | 29 |
| Mar-17 | 39 | 39 | 38 | 38 | 38 |
| Apr-02 | 27 | 27 | 16 | 27 | 28 |
| Apr-16 | 26 | 26 | 19 | 26 | 24 |
| May-05 | 42 | 42 | 160 | 44 | 46 |
| May-19 | 81 | 42 | 75 | 45 | 45 |
| Jun-04 | 36 | 40 | * | 40 | 48 |
| Jun-17 | 60 | 60 | 220 | 60 | 60 |
| Jul-01 | 64 | 70 | 180 | 66 | 64 |
| Jul-16 | 72 | 65 | 150 | 72 | 64 |
| Aug-06 | 40 | 40 | 81 | 40 | 40 |
| Aug-20 | 34 | 35 | 26 | 33 | 33 |
| Sep-03 | 38 | 36 | 56 | 40 | 38 |
| Sep-17 | 32 | 28 | 120 | 36 | 35 |
| Oct-02 | 19 | 20 | 56 | 36 | 22 |
| Oct-16 | 68 | 56 | 40 | 70 | 66 |
| Nov-03 | 10 | 10 | 14 | 11 | 10 |
| Nov-19 | 4 | 4 | 8 | 4 | 4 |
| Dec-03 | 4 | 4 | 700 | 5 | 6 |
| Dec-17 | 4 | 10 | 8 | 5 | 5 |

*Not sampled

Table 5

Total Solids (mg/L) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 320 | 310 | 330 | 350 | 340 |
| Jan-22 | 370 | 400 | 220 | 420 | 410 |
| Feb-05 | 330 | 340 | 350 | 360 | 360 |
| Feb-19 | 410 | 410 | 120 | 470 | 420 |
| Mar-06 | 270 | 290 | 710 | 290 | 280 |
| Mar-17 | 230 | 230 | 230 | 230 | 230 |
| Apr-02 | 300 | 300 | 510 | 310 | 310 |
| Apr-16 | 380 | 380 | 1270 | 410 | 410 |
| May-05 | 420 | 410 | 1900 | 420 | 430 |
| May-19 | 460 | 400 | 1500 | 420 | 420 |
| Jun-04 | 380 | 370 | * | 390 | 420 |
| Jun-17 | 410 | 430 | 2010 | 440 | 440 |
| Jul-01 | 420 | 460 | 1540 | 490 | 460 |
| Jul-16 | 460 | 490 | 2370 | 500 | 520 |
| Aug-06 | 380 | 390 | 2020 | 410 | 410 |
| Aug-20 | 330 | 340 | 1040 | 360 | 372 |
| Sep-03 | 340 | 340 | 1540 | 430 | 380 |
| Sep-17 | 330 | 320 | 1600 | 390 | 370 |
| Oct-02 | 330 | 320 | 1760 | 590 | 390 |
| Oct-16 | 440 | 470 | 1530 | 480 | 500 |
| Nov-03 | 380 | 380 | 1530 | 400 | 400 |
| Nov-19 | 390 | 380 | 1690 | 400 | 410 |
| Dec-03 | 350 | 350 | 860 | 390 | 380 |
| Dec-17 | 370 | 370 | 790 | 400 | 400 |

*Not sampled

Table 6

Dissolved Solids (mg/L) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 270 | 270 | 280 | 290 | 280 |
| Jan-22 | 340 | 370 | 210 | 390 | 380 |
| Feb-05 | 320 | 320 | 340 | 340 | 330 |
| Feb-19 | 140 | 160 | 110 | 170 | 170 |
| Mar-06 | 220 | 220 | 660 | 230 | 220 |
| Mar-17 | 190 | 180 | 190 | 190 | 190 |
| Apr-02 | 260 | 250 | 480 | 260 | 260 |
| Apr-16 | 320 | 320 | 1200 | 330 | 340 |
| May-05 | 300 | 300 | 1580 | 300 | 300 |
| May-19 | 300 | 300 | 1310 | 310 | 310 |
| Jun-04 | 270 | 260 | * | 270 | 280 |
| Jun-17 | 270 | 270 | 1620 | 280 | 300 |
| Jul-01 | 310 | 310 | 1200 | 320 | 320 |
| Jul-16 | 320 | 330 | 2020 | 350 | 350 |
| Aug-06 | 280 | 270 | 1890 | 280 | 300 |
| Aug-20 | 240 | 250 | 1020 | 270 | 270 |
| Sep-03 | 230 | 230 | 1350 | 310 | 260 |
| Sep-17 | 240 | 230 | 1290 | 270 | 260 |
| Oct-02 | 260 | 250 | 1520 | 420 | 310 |
| Oct-16 | 300 | 300 | 1400 | 330 | 310 |
| Nov-03 | 360 | 350 | 1420 | 370 | 380 |
| Nov-19 | 360 | 360 | 1570 | 370 | 370 |
| Dec-03 | 330 | 330 | 380 | 360 | 350 |
| Dec-17 | 350 | 350 | 750 | 380 | 380 |

*Not sampled

Table 7

Suspended Solids (mg/L) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 38 | 32 | 28 | 35 | 37 |
| Jan-22 | 13 | 12 | 15 | 14 | 14 |
| Feb-05 | 10 | 11 | 4 | 12 | 11 |
| Feb-19 | 260 | 240 | 7 | 280 | 250 |
| Mar-06 | 38 | 61 | 10 | 54 | 46 |
| Mar-17 | 42 | 35 | 33 | 37 | 36 |
| Apr-02 | 45 | 43 | 13 | 42 | 42 |
| Apr-16 | 44 | 47 | 18 | 47 | 47 |
| May-05 | 91 | 85 | 230 | 90 | 93 |
| May-19 | 140 | 82 | 128 | 93 | 97 |
| Jun-04 | 87 | 94 | * | 91 | 120 |
| Jun-17 | 140 | 150 | 350 | 140 | 140 |
| Jul-01 | 110 | 150 | 260 | 130 | 130 |
| Jul-16 | 140 | 140 | 240 | 150 | 160 |
| Aug-06 | 85 | 84 | 110 | 86 | 85 |
| Aug-20 | 74 | 74 | 47 | 69 | 79 |
| Sep-03 | 84 | 77 | 86 | 83 | 80 |
| Sep-17 | 69 | 67 | 210 | 80 | 72 |
| Oct-02 | 52 | 56 | 110 | 130 | 56 |
| Oct-16 | 140 | 150 | 43 | 150 | 160 |
| Nov-03 | 12 | 11 | 12 | 13 | 12 |
| Nov-19 | 6 | 7 | 9 | 7 | 8 |
| Dec-03 | 7 | 7 | 450 | 8 | 8 |
| Dec-17 | 5 | 4 | 11 | 5 | 5 |

*Not sampled

Table 8

Dissolved Oxygen (mg/L) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| | Sampling Locations | | | | |
|---|---|---|---|---|---|
| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 11.5 | 11.6 | 12.7 | 11.3 | 11.6 |
| Jan-22 | 12.5 | 10.8 | 11.7 | 10.7 | 10.8 |
| Feb-05 | 11.0 | 11.1 | 8.9 | 11.1 | 11.1 |
| Feb-19 | 12.3 | 11.8 | 11.8 | 12.0 | 12.5 |
| Mar-06 | 12.1 | 12.1 | 9.2 | 12.0 | 11.9 |
| Mar-17 | 13.0 | 13.2 | 14.5 | 13.2 | 13.5 |
| Apr-02 | 12.0 | 11.9 | 10.3 | 11.7 | 11.7 |
| Apr-16 | 12.7 | 13.0 | 10.1 | 12.9 | 12.8 |
| May-05 | 10.8 | 11.1 | 6.9 | 10.6 | 10.6 |
| May-19 | 12.1 | 13.0 | 10.3 | 12.5 | 12.8 |
| Jun-04 | 12.7 | 12.7 | * | 12.8 | 13.0 |
| Jun-17 | 9.4 | 10.1 | 6.9 | 9.8 | 8.3 |
| Jul-01 | 7.6 | 7.5 | 8.0 | 8.9 | 8.0 |
| Jul-16 | 9.4 | 8.7 | 7.1 | 8.6 | 8.3 |
| Aug-06 | 8.2 | 8.2 | 6.4 | 8.3 | 8.4 |
| Aug-20 | 10.8 | 12.5 | 6.1 | 12.8 | 12.5 |
| Sep-03 | 8.8 | 10.0 | 6.5 | 9.7 | 11.5 |
| Sep-17 | 10.4 | 14.9 | 6.6 | 14.4 | 16.9 |
| Oct-02 | 13.5 | 13.8 | 7.4 | 13.7 | 16.9 |
| Oct-16 | 10.4 | 11.2 | 7.2 | 11.2 | 11.7 |
| Nov-03 | 12.4 | 12.0 | 10.0 | 12.0 | 12.5 |
| Nov-19 | 19.7 | 19.8 | 12.9 | 19.5 | 17.8 |
| Dec-03 | 12.6 | 13.2 | 11.3 | 12.8 | 13.2 |
| Dec-17 | 14.9 | 14.4 | 10.3 | 13.9 | 13.8 |

*Not sampled

Table 9

Carbon Dioxide (mg/L) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 12 | 15 | 7 | 9 | 9 |
| Jan-22 | 15 | 14 | 2 | 11 | 14 |
| Feb-05 | 16 | 10 | 10 | 10 | 10 |
| Feb-19 | 11 | 9 | 5 | 10 | 10 |
| Mar-06 | 18 | 11 | 10 | 9 | 15 |
| Mar-17 | 6 | 7 | 5 | 7 | 6 |
| Apr-02 | 4 | 4 | 3 | 4 | 4 |
| Apr-16 | 4 | 4 | ** | 4 | 3 |
| May-05 | 4 | 3 | ** | 3 | 3 |
| May-19 | 3 | 3 | ** | 3 | 3 |
| Jun-04 | 4 | 2 | * | <1 | <1 |
| Jun-17 | 2 | 2 | ** | 2 | <1 |
| Jul-01 | 2 | 2 | ** | 2 | 2 |
| Jul-16 | <1 | <1 | ** | <1 | <1 |
| Aug-06 | 1 | 1 | 3 | 1 | 1 |
| Aug-20 | <1 | <1 | ** | <1 | <1 |
| Sep-03 | <1 | <1 | ** | <1 | <1 |
| Sep-17 | 2 | <1 | ** | <1 | <1 |
| Oct-02 | <1 | <1 | ** | <1 | <1 |
| Oct-16 | 5 | 4 | ** | 3 | 4 |
| Nov-03 | <1 | <1 | * | <1 | 2 |
| Nov-19 | <1 | <1 | * | <1 | <1 |
| Dec-03 | <1 | <1 | 4 | <1 | <1 |
| Dec-17 | <1 | <1 | 2 | <1 | <1 |

*Not sampled

**Unable to calculate

Table 10

Total Alkalinity (mg/L) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| | Sampling Locations | | | | |
|---|---|---|---|---|---|
| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 152 | 154 | 154 | 150 | 150 |
| Jan-22 | 228 | 240 | 58 | 236 | 240 |
| Feb-05 | 208 | 198 | 184 | 200 | 200 |
| Feb-19 | 94 | 94 | 44 | 98 | 98 |
| Mar-06 | 146 | 144 | 180 | 140 | 146 |
| Mar-17 | 120 | 116 | 116 | 110 | 116 |
| Apr-02 | 172 | 172 | 158 | 174 | 178 |
| Apr-16 | 204 | 202 | 160 | 204 | 208 |
| May-05 | 176 | 176 | 144 | 174 | 176 |
| May-19 | 180 | 184 | 122 | 194 | 188 |
| Jun-04 | 170 | 168 | * | 174 | 172 |
| Jun-17 | 158 | 154 | 109 | 150 | 154 |
| Jul-01 | 194 | 178 | 126 | 162 | 194 |
| Jul-16 | 196 | 204 | 136 | 208 | 208 |
| Aug-06 | 156 | 156 | 116 | 156 | 152 |
| Aug-20 | 118 | 110 | 80 | 136 | 116 |
| Sep-03 | 154 | 150 | 122 | 150 | 154 |
| Sep-17 | 144 | 144 | 96 | 140 | 132 |
| Oct-02 | 150 | 144 | 116 | 144 | 149 |
| Oct-16 | 178 | 176 | 176 | 178 | 164 |
| Nov-03 | 222 | 187 | 130 | 188 | 208 |
| Nov-19 | 222 | 208 | 164 | 220 | 220 |
| Dec-03 | 196 | 206 | 316 | 184 | 198 |
| Dec-17 | 214 | 214 | 118 | 210 | 202 |

*Not sampled

Table 11

Carbonate Alkalinity (mg/L $CaCO_3$) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | <1 | <1 | <1 | <1 | <1 |
| Jan-22 | <1 | <1 | <1 | <1 | <1 |
| Feb-05 | <1 | <1 | <1 | <1 | <1 |
| Feb-19 | <1 | <1 | <1 | <1 | <1 |
| Mar-06 | <1 | <1 | <1 | <1 | <1 |
| Mar-17 | <1 | <1 | <1 | <1 | <1 |
| Apr-02 | <1 | <1 | <1 | <1 | <1 |
| Apr-16 | <1 | <1 | <1 | <1 | <1 |
| May-05 | <1 | <1 | <1 | <1 | <1 |
| May-19 | <1 | <1 | <1 | <1 | <1 |
| Jun-04 | <1 | <1 | * | 2 | 6 |
| Jun-17 | <1 | <1 | <1 | <1 | 2 |
| Jul-01 | <1 | <1 | <1 | <1 | <1 |
| Jul-16 | 8 | 12 | <1 | 10 | 10 |
| Aug-06 | <1 | <1 | <1 | <1 | <1 |
| Aug-20 | 2 | 6 | <1 | 4 | 4 |
| Sep-03 | 2 | 4 | <1 | 4 | 4 |
| Sep-17 | <1 | 10 | <1 | 8 | 8 |
| Oct-02 | 12 | 12 | <1 | 10 | 13 |
| Oct-16 | <1 | <1 | <1 | <1 | <1 |
| Nov-03 | 10 | 12 | <1 | 12 | <1 |
| Nov-19 | 8 | 6 | <1 | 10 | 8 |
| Dec-03 | 2 | 2 | <1 | 2 | 2 |
| Dec-17 | 4 | 2 | <1 | 2 | 2 |

*Not sampled

Table12

Units of pH Values for the Cedar River
near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 7.6 | 7.5 | 7.8 | 7.7 | 7.7 |
| Jan-22 | 7.6 | 7.7 | 7.9 | 7.8 | 7.7 |
| Feb-05 | 7.6 | 7.8 | 7.6 | 7.8 | 7.7 |
| Feb-19 | 7.4 | 7.5 | 7.4 | 7.5 | 7.4 |
| Mar-06 | 7.4 | 7.6 | 7.7 | 7.7 | 7.5 |
| Mar-17 | 7.8 | 7.7 | 7.8 | 7.7 | 7.8 |
| Apr-02 | 8.0 | 8.1 | 8.1 | 8.1 | 8.1 |
| Apr-16 | 8.2 | 8.1 | 7.8 | 8.2 | 8.2 |
| May-05 | 8.1 | 8.1 | 7.7 | 8.1 | 8.1 |
| May-19 | 8.2 | 8.2 | 7.7 | 8.2 | 8.1 |
| Jun-04 | 8.0 | 8.3 | * | 8.4 | 8.4 |
| Jun-17 | 8.2 | 8.2 | 7.8 | 8.3 | 8.4 |
| Jul-01 | 8.3 | 8.3 | 8.1 | 8.3 | 8.3 |
| Jul-16 | 8.5 | 8.6 | 8.0 | 8.6 | 8.6 |
| Aug-06 | 8.3 | 8.3 | 7.9 | 8.3 | 8.3 |
| Aug-20 | 8.6 | 8.7 | 7.5 | 8.7 | 8.7 |
| Sep-03 | 8.5 | 8.6 | 7.8 | 8.5 | 8.6 |
| Sep-17 | 8.3 | 8.7 | 7.7 | 8.6 | 9.0 |
| Oct-02 | 8.6 | 8.7 | 7.9 | 8.6 | 8.9 |
| Oct-16 | 7.9 | 8.0 | 7.6 | 8.1 | 8.0 |
| Nov-03 | 8.4 | 8.5 | 7.8 | 8.4 | 8.3 |
| Nov-19 | 8.7 | 8.7 | 8.1 | 8.7 | 8.7 |
| Dec-03 | 8.7 | 8.8 | 8.3 | 8.8 | 8.7 |
| Dec-17 | 8.8 | 8.8 | 8.3 | 8.8 | 8.8 |

*Not sampled

Table 13

Total Hardness (mg/L $CaCO_3$) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant 1 | Upstream of Plant Intake 2 | Discharge Canal 5 | 140 Feet Downstream of Discharge 3 | 1/2 Mile Downstream from Plant 4 |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| Jan-08 | 140 | 140 | 150 | 150 | 150 |
| Jan-22 | 320 | 360 | 180 | 380 | 380 |
| Feb-05 | 240 | 240 | 250 | 240 | 250 |
| Feb-19 | 120 | 150 | 110 | 160 | 200 |
| Mar-06 | 240 | 200 | 460 | 200 | 200 |
| Mar-17 | 160 | 140 | 200 | 200 | 160 |
| Apr-02 | 230 | 250 | 370 | 250 | 260 |
| Apr-16 | 310 | 350 | 880 | 320 | 310 |
| May-05 | 270 | 270 | 1100 | 300 | 300 |
| May-19 | 280 | 310 | 930 | 300 | 350 |
| Jun-04 | 250 | 180 | * | 340 | 300 |
| Jun-17 | 300 | 240 | 1200 | 260 | 330 |
| Jul-01 | 260 | 270 | 820 | 320 | 270 |
| Jul-16 | 270 | 270 | 1300 | 280 | 290 |
| Aug-06 | 230 | 240 | 1200 | 280 | ** |
| Aug-20 | 200 | 230 | 660 | 220 | 220 |
| Sep-03 | 190 | 210 | 800 | 220 | 200 |
| Sep-17 | 190 | 180 | 760 | 210 | 200 |
| Oct-02 | 240 | 230 | 1000 | 340 | 280 |
| Oct-16 | 250 | 240 | 970 | 260 | 260 |
| Nov-03 | 280 | 340 | 980 | 360 | 300 |
| Nov-19 | 280 | 280 | 1000 | 280 | 290 |
| Dec-03 | 340 | 340 | 370 | 320 | 380 |
| Dec-17 | 350 | 320 | 500 | 360 | 320 |

*Not sampled

**Analytical problems

Table 14

Calcium Hardness (mg/L $CaCO_3$) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| | Sampling Locations | | | | |
|---|---|---|---|---|---|
| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 85 | 100 | 100 | 100 | 100 |
| Jan-22 | 210 | 200 | 92 | 210 | 210 |
| Feb-05 | 150 | 170 | 170 | 180 | 180 |
| Feb-19 | 84 | 84 | 60 | 92 | 80 |
| Mar-06 | 140 | 140 | 340 | 140 | 140 |
| Mar-17 | 100 | 120 | 140 | 110 | 100 |
| Apr-02 | 150 | 150 | 240 | 150 | 150 |
| Apr-16 | 200 | 200 | 570 | 190 | 200 |
| May-05 | 180 | 170 | 730 | 190 | 180 |
| May-19 | 220 | 220 | 620 | 200 | 200 |
| Jun-04 | 140 | 150 | * | 140 | 140 |
| Jun-17 | 140 | 130 | 590 | 140 | 140 |
| Jul-01 | 190 | 170 | 560 | 180 | 180 |
| Jul-16 | 170 | 180 | 860 | 190 | 180 |
| Aug-06 | 140 | 140 | 790 | 140 | 150 |
| Aug-20 | 110 | 100 | 360 | 110 | 120 |
| Sep-03 | 100 | 80 | 410 | 110 | 100 |
| Sep-17 | 100 | 100 | 480 | 100 | 110 |
| Oct-02 | 120 | 140 | 580 | 210 | 130 |
| Oct-16 | 170 | 180 | 580 | 180 | 170 |
| Nov-03 | 180 | 220 | 690 | 220 | 220 |
| Nov-19 | 190 | 190 | 650 | 200 | 200 |
| Dec-03 | 200 | 200 | 200 | 200 | 240 |
| Dec-17 | 240 | 210 | 320 | 210 | 210 |

*Not sampled

Table 15

Total Phosphorus (mg/L-P) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant 1 | Upstream of Plant Intake 2 | Discharge Canal 5 | 140 Feet Downstream of Discharge 3 | 1/2 Mile Downstream from Plant 4 |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| Jan-08 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Jan-22 | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 |
| Feb-05 | 0.3 | 0.3 | 0.3 | 0.3 | 0.4 |
| Feb-19 | 1.1 | 1.0 | 0.3 | 1.1 | 1.0 |
| Mar-06 | 0.5 | 0.5 | 1.1 | 0.5 | 0.5 |
| Mar-17 | 0.4 | 0.5 | 0.4 | 0.5 | 0.4 |
| Apr-02 | 0.3 | 0.3 | 0.5 | 0.3 | 0.3 |
| Apr-16 | 0.2 | 0.2 | 0.8 | 0.2 | 0.2 |
| May-05 | 0.2 | 0.2 | 2.2 | 0.2 | 0.2 |
| May-19 | 0.3 | 0.2 | 1.5 | 0.2 | 0.2 |
| Jun-04 | 0.2 | 0.2 | * | 0.2 | 0.2 |
| Jun-17 | 0.2 | 0.3 | 2.3 | 0.3 | 0.3 |
| Jul-01 | 0.4 | 0.4 | 1.3 | 0.3 | 0.4 |
| Jul-16 | 0.4 | 0.3 | 1.7 | 0.4 | 0.3 |
| Aug-06 | 0.2 | 0.2 | 2.0 | 0.3 | 0.2 |
| Aug-20 | 0.2 | 0.4 | 1.5 | 0.2 | 0.3 |
| Sep-03 | 0.3 | 0.3 | 1.9 | 0.4 | 0.2 |
| Sep-17 | 0.1 | 0.1 | 1.9 | 0.2 | 0.2 |
| Oct-02 | 0.2 | 0.2 | 2.3 | 0.4 | 0.3 |
| Oct-16 | 0.3 | 0.3 | 2.3 | 0.3 | 0.3 |
| Nov-03 | 0.2 | 0.2 | 1.3 | 0.2 | 0.2 |
| Nov-19 | 0.2 | 0.1 | 1.5 | 0.2 | 0.2 |
| Dec-03 | 0.2 | 0.2 | 0.8 | 0.2 | 0.2 |
| Dec-17 | 0.2 | 0.2 | 0.9 | 0.2 | 0.2 |

*Not sampled

Table 16

Soluble Orthophosphate (mg/L-P) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 0.3 | 0.3 | 0.4 | 0.4 | 0.4 |
| Jan-22 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Feb-05 | 0.3 | 0.3 | 0.1 | 0.3 | 0.3 |
| Feb-19 | 0.6 | 0.5 | 0.2 | 0.5 | 0.5 |
| Mar-06 | 0.3 | 0.3 | 0.7 | 0.3 | 0.3 |
| Mar-17 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Apr-02 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 |
| Apr-16 | <0.1 | <0.1 | 0.5 | 0.1 | <0.1 |
| May-05 | <0.1 | <0.1 | 0.7 | <0.1 | <0.1 |
| May-19 | <0.1 | <0.1 | 1.0 | <0.1 | <0.1 |
| Jun-04 | <0.1 | <0.1 | * | <0.1 | <0.1 |
| Jun-17 | 0.1 | 0.1 | 0.8 | 0.1 | 0.1 |
| Jul-01 | 0.1 | 0.2 | 0.6 | 0.2 | 0.2 |
| Jul-16 | 0.1 | <0.1 | 0.7 | 0.1 | 0.1 |
| Aug-06 | <0.1 | <0.1 | 0.8 | <0.1 | <0.1 |
| Aug-20 | <0.1 | <0.1 | 0.7 | <0.1 | <0.1 |
| Sep-03 | <0.1 | <0.1 | 0.6 | <0.1 | <0.1 |
| Sep-17 | <0.1 | <0.1 | 0.7 | <0.1 | <0.1 |
| Oct-02 | <0.1 | <0.1 | 0.7 | <0.1 | <0.1 |
| Oct-16 | 0.2 | 0.2 | 1.5 | 0.2 | 0.2 |
| Nov-03 | 0.2 | 0.1 | 0.8 | 0.2 | 0.2 |
| Nov-19 | 0.1 | 0.1 | 0.8 | 0.1 | 0.1 |
| Dec-03 | 0.2 | 0.1 | 0.2 | 0.2 | 0.2 |
| Dec-17 | 0.2 | 0.2 | 0.4 | 0.2 | 0.2 |

*Not sampled

Table 17

Ammonia (mg/L-N) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Jan-22 | 0.4 | 0.5 | 0.4 | 0.5 | 0.5 |
| Feb-05 | 0.6 | 0.6 | <0.1 | 0.6 | 0.6 |
| Feb-19 | 1.0 | 1.0 | 0.2 | 1.0 | 1.0 |
| Mar-06 | 0.8 | 0.8 | 0.5 | 0.8 | 0.7 |
| Mar-17 | 0.4 | 0.5 | 0.4 | 0.5 | 0.4 |
| Apr-02 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 |
| Apr-16 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| May-05 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 |
| May-19 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Jun-04 | <0.1 | <0.1 | * | <0.1 | <0.1 |
| Jun-17 | <0.1 | <0.1 | 0.2 | <0.1 | <0.1 |
| Jul-01 | <0.1 | <0.1 | 1.5 | <0.1 | <0.1 |
| Jul-16 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 |
| Aug-06 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 |
| Aug-20 | <0.1 | <0.1 | 0.3 | <0.1 | <0.1 |
| Sep-03 | <0.1 | <0.1 | 0.4 | <0.1 | <0.1 |
| Sep-17 | <0.1 | <0.1 | 0.3 | <0.1 | <0.1 |
| Oct-02 | <0.1 | <0.1 | 0.2 | <0.1 | <0.1 |
| Oct-16 | <0.1 | <0.1 | 2.0 | <0.1 | <0.1 |
| Nov-03 | <0.1 | <0.1 | 0.4 | <0.1 | <0.1 |
| Nov-19 | <0.1 | <0.1 | 0.3 | <0.1 | <0.1 |
| Dec-03 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 |
| Dec-17 | <0.1 | <0.1 | 0.2 | 0.1 | 0.1 |

*Not sampled

Table 18

Nitrate (mg/L)-N Values for the Cedar River
near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 5.1 | 4.9 | 5.1 | 5.2 | 5.0 |
| Jan-22 | 5.2 | 5.7 | 1.6 | 5.9 | 5.8 |
| Feb-05 | 4.7 | 4.7 | 1.3 | 5.0 | 4.9 |
| Feb-19 | 1.5 | 1.8 | 0.9 | 2.0 | 1.9 |
| Mar-06 | 2.4 | 2.6 | 5.4 | 2.6 | 2.6 |
| Mar-17 | 2.9 | 2.6 | 2.6 | 2.7 | 2.8 |
| Apr-02 | 5.3 | 5.3 | 6.7 | 5.3 | 5.3 |
| Apr-16 | 7.3 | 7.4 | 17 | 7.6 | 7.6 |
| May-05 | 10 | 10 | 10 | 10 | 10 |
| May-19 | 7.5 | 7.6 | 22 | 7.6 | 7.7 |
| Jun-04 | 6.2 | 6.1 | * | 6.4 | 6.3 |
| Jun-17 | 6.1 | 5.8 | 9.2 | 6.0 | 6.1 |
| Jul-01 | 8.9 | 8.6 | 22 | 8.8 | 8.2 |
| Jul-16 | 5.7 | 6.0 | 25 | 6.1 | 6.1 |
| Aug-06 | 5.0 | 5.0 | 22 | 5.3 | 5.5 |
| Aug-20 | 2.0 | 1.9 | 5.4 | 1.9 | 1.9 |
| Sep-03 | 1.3 | 1.1 | 3.7 | 1.3 | 1.2 |
| Sep-17 | 1.4 | 1.1 | 4.1 | 1.2 | 1.1 |
| Oct-02 | 2.1 | 1.6 | 6.8 | 2.3 | 1.9 |
| Oct-16 | 6.4 | 6.4 | 11 | 6.6 | 6.4 |
| Nov-03 | 6.8 | 6.6 | 16 | 6.8 | 6.9 |
| Nov-19 | 5.4 | 5.2 | 12 | 5.4 | 5.4 |
| Dec-03 | 6.8 | 6.4 | 3.6 | 6.7 | 6.8 |
| Dec-17 | 6.0 | 6.2 | 6.7 | 6.2 | 6.2 |

*Not sampled

Table 19

Total Iron (mg/L) Values for the Cedar River
near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | Sampling Locations | | | | |
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 1.8 | 1.7 | 1.5 | 1.8 | 1.7 |
| Jan-22 | 0.51 | 0.48 | 0.51 | 0.50 | 0.48 |
| Feb-05 | 0.51 | 0.49 | 0.26 | 0.53 | 0.55 |
| Feb-19 | 8.8 | 9.0 | 0.24 | 7.8 | 8.4 |
| Mar-06 | 1.4 | 2.0 | 0.79 | 1.7 | 1.6 |
| Mar-17 | 2.1 | 1.8 | 1.9 | 1.9 | 1.9 |
| Apr-02 | 1.7 | 1.7 | 0.86 | 1.7 | 1.7 |
| Apr-16 | 1.4 | 1.5 | 0.90 | 1.5 | 1.5 |
| May-05 | 2.6 | 2.2 | 7.3 | 2.5 | 2.3 |
| May-19 | 4.6 | 2.4 | 3.6 | 2.4 | 2.9 |
| Jun-04 | 1.4 | 1.6 | * | 1.4 | 1.9 |
| Jun-17 | 2.8 | 3.2 | 10 | 2.9 | 3.4 |
| Jul-01 | 3.7 | 4.6 | 7.7 | 4.1 | 4.6 |
| Jul-16 | 4.6 | 4.5 | 10 | 4.0 | 3.9 |
| Aug-06 | 1.3 | 1.1 | 3.0 | 1.4 | 1.2 |
| Aug-20 | 0.67 | 1.1 | 0.80 | 0.63 | 0.98 |
| Sep-03 | 1.4 | 1.4 | 1.5 | 0.89 | 1.1 |
| Sep-17 | 0.62 | 0.58 | 3.8 | 0.64 | 0.68 |
| Oct-02 | 0.36 | 0.34 | 1.4 | 1.5 | 0.46 |
| Oct-16 | 3.2 | 2.7 | 2.0 | 2.9 | 2.9 |
| Nov-03 | 0.36 | 0.35 | 0.91 | 0.42 | 0.33 |
| Nov-19 | 0.18 | 0.21 | 0.63 | 0.23 | 0.22 |
| Dec-03 | 0.19 | 0.19 | 5.20 | 0.19 | 0.19 |
| Dec-17 | 0.18 | 0.18 | 0.44 | 0.19 | 0.19 |

*Not sampled

Table 20

Biochemical Oxygen Demand (5 day in mg/L) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 7 | 7 | 7 | 6 | 7 |
| Jan-22 | 3 | 2 | 4 | 2 | 2 |
| Feb-05 | 2 | 2 | 1 | 3 | 3 |
| Feb-19 | 21 | 19 | 4 | 19 | 19 |
| Mar-06 | 7 | 6 | 3 | 6 | 6 |
| Mar-17 | 4 | 6 | 6 | 4 | 6 |
| Apr-02 | 2 | 2 | 2 | 2 | 2 |
| Apr-16 | 3 | 3 | 3 | 3 | 3 |
| May-05 | 4 | 4 | 7 | 4 | 5 |
| May-19 | 5 | 5 | 8 | 4 | 4 |
| Jun-04 | 8 | 9 | * | 9 | 10 |
| Jun-17 | 8 | 8 | 11 | 8 | 8 |
| Jul-01 | 3 | 3 | 5 | 3 | 3 |
| Jul-16 | 4 | 4 | 12 | 4 | 4 |
| Aug-06 | 7 | 8 | 11 | 9 | 7 |
| Aug-20 | 11 | 12 | 11 | 12 | 12 |
| Sep-03 | 8 | 8 | 13 | 8 | 8 |
| Sep-17 | 11 | 12 | 21 | 13 | 12 |
| Oct-02 | 10 | 11 | 19 | 13 | 11 |
| Oct-16 | 3 | 2 | 3 | 3 | 3 |
| Nov-03 | 2 | 1 | 1 | 2 | 2 |
| Nov-19 | 2 | 2 | 2 | 2 | 2 |
| Dec-03 | 1 | 1 | 2 | 2 | 1 |
| Dec-17 | <1 | 1 | 4 | 1 | 2 |

*Not sampled

Table 21

Coliform Bacteria (Fecal Organisms/100 ml) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Sampling Locations: Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 1700 | 2000 | 1600 | 2600 | 2300 |
| Jan-22 | 380 | 480 | 1500 | 390 | 320 |
| Feb-05 | 720 | 550 | <10 | 700 | 590 |
| Feb-19 | 800 | 740 | 82 | 740 | 730 |
| Mar-06 | 190 | 100 | <10 | 150 | 72 |
| Mar-17 | 130 | 150 | 140 | 110 | 110 |
| Apr-02 | 310 | 230 | <10 | 200 | 190 |
| Apr-16 | 240 | 200 | 20 | 240 | 200 |
| May-05 | 380 | 540 | 700 | 360 | 400 |
| May-19 | 562 | 270 | 550 | 150 | 150 |
| Jun-04 | 30 | 10 | * | 36 | 50 |
| Jun-17 | 600 | 810 | 4900 | 810 | 760 |
| Jul-01 | 900 | 400 | 5500 | 1000 | 500 |
| Jul-16 | 310 | 300 | 1100 | 360 | 320 |
| Aug-06 | 40 | 27 | 2400 | 70 | 40 |
| Aug-20 | 40 | 60 | 600 | 55 | 91 |
| Sep-03 | 4200 | 800 | 3000 | 1600 | 2500 |
| Sep-17 | 360 | 84 | 37000 | 500 | 120 |
| Oct-02 | 45 | 20 | 300 | 10 | 20 |
| Oct-16 | 2400 | 3600 | 2900 | 2400 | 2400 |
| Nov-03 | 64 | 73 | 2300 | 45 | 30 |
| Nov-19 | 30 | 10 | 3100 | <10 | <10 |
| Dec-03 | 170 | 100 | 55,000 | 130 | 190 |
| Dec-17 | 10 | <10 | 250 | 10 | 10 |

*Not sampled

Table 22

Coliform Bacteria (E. coli/100 ml) Values for the Cedar River near the Duane Arnold Energy Center during 1997

| Date 1997 | Upstream of Plant | Upstream of Plant Intake | Discharge Canal | 140 Feet Downstream of Discharge | 1/2 Mile Downstream from Plant |
|---|---|---|---|---|---|
| | 1 | 2 | 5 | 3 | 4 |
| Jan-08 | 2600 | 2000 | 3000 | 2200 | 2100 |
| Jan-22 | 580 | 420 | 1700 | 390 | 320 |
| Feb-05 | 670 | 560 | <10 | 540 | 510 |
| Feb-19 | 1200 | 800 | 120 | 470 | 420 |
| Mar-06 | 110 | 100 | <10 | 150 | 72 |
| Mar-17 | 180 | 200 | 140 | 180 | 110 |
| Apr-02 | 320 | 210 | <10 | 140 | 160 |
| Apr-16 | 250 | 170 | 82 | 170 | 160 |
| May-05 | 520 | 180 | 830 | 300 | 240 |
| May-19 | 470 | 290 | 590 | 240 | 260 |
| Jun-04 | 20 | <10 | * | 20 | 36 |
| Jun-17 | 870 | 1100 | 850 | 980 | 960 |
| Jul-01 | 730 | 700 | 1200 | 690 | 910 |
| Jul-16 | 480 | 410 | 130 | 340 | 320 |
| Aug-06 | 60 | 9 | 2000 | 50 | 50 |
| Aug-20 | 20 | 91 | 270 | 91 | 64 |
| Sep-03 | 5100 | 950 | 2600 | 1100 | 3000 |
| Sep-17 | 340 | 50 | 1100 | 130 | 150 |
| Oct-02 | 20 | 10 | 200 | 70 | 50 |
| Oct-16 | 1800 | 3100 | 4100 | 4000 | 2100 |
| Nov-03 | 130 | 100 | 2200 | 60 | 40 |
| Nov-19 | 10 | 10 | 2300 | 27 | 10 |
| Dec-03 | 190 | 82 | 78,000 | 170 | 200 |
| Dec-17 | 20 | <10 | 220 | 10 | 10 |

*Not sampled

Table 23

Additional Chemical Analysis-1997

| Station | $Cl^-$ (mg/L) | $SO_4$ (mg/L) | Metals (ug/L) Cr | Cu | Pb | Mn | Hg | Zn |
|---|---|---|---|---|---|---|---|---|
| | | | Apr-16 | | | | | |
| 1. Lewis Access | 19 | 39 | <20 | <10 | <10 | 80 | <1 | <20 |
| 2. Upstream DAEC | 22 | 35 | <20 | <10 | <10 | 80 | <1 | <20 |
| 3. Downstream DAEC | 22 | 39 | <20 | <10 | <10 | 80 | <1 | <20 |
| 4. One-half mile below plant | 22 | 41 | <20 | <10 | <10 | 80 | <1 | <20 |
| 5. Discharge Canal | 70 | 570 | <20 | <10 | <10 | 130 | <1 | 160 |
| | | | Aug-06 | | | | | |
| 1. Lewis Access | 24 | 36 | <20 | <10 | <10 | 100 | <1 | <20 |
| 2. Upstream DAEC | 26 | 37 | <20 | <10 | <10 | 90 | <1 | <20 |
| 3. Downstream DAEC | 24 | 44 | <20 | <10 | <10 | 110 | <1 | <20 |
| 4. One-half mile below plant | 27 | 44 | <20 | <10 | <10 | 100 | <1 | <20 |
| 5. Discharge Canal | 100 | 920 | <20 | 10 | <10 | 210 | <1 | 340 |

Table 24

Benthic macroinvertebrates collected on Hester-Dendy artificial substrates from the Cedar River and the discharge canal in the vicinity of the Duane Arnold Energy Center, 7/1/97-8/11/97.

| Taxon | Lewis Access | U/S DAEC | D/S DAEC | ¼ mi. Below plant | Disc. Canal |
|---|---|---|---|---|---|
| Arthropoda | | | | | |
| Insecta | | | | | |
| Coleoptera (Beetles) | | | | | |
| Elmidae | | | | | |
| *Stenelmis* spp. | | | 3 | | |
| Diptera | | | | | |
| Chironomidae | 48 | 154 | 35 | 52 | 49 |
| Simuliidae | | | | | |
| *Simulium* spp. | 20 | 24 | 2 | | |
| Empididae | 4 | | 1 | | |
| *Hemerodromia* spp | | | | 2 | |
| Ephemeroptera (Mayflies) | | | | | |
| Baetidae | | | | | |
| *Baetis brunneicolor* | | | 3 | | |
| *Baetis intercalaris* | | 13 | | | |
| *Baetis* spp. | 4 | 13 | | 15 | |
| *Falceon quilleri* | | 11 | | | |
| *Labiobaetis longipalpus* | 41 | 41 | 44 | 17 | |
| Caenidae | | | | | |
| *Caenis* spp. | 5 | 2 | | 20 | |
| Heptageniidae | | | | | |
| *Heptagenia diabasia* | 1 | | 1 | | |
| *Heptagenia pulla* | 14 | 29 | 29 | 18 | |
| *Stenonema exiguum* | | 3 | 1 | 2 | |
| *Stenonema integrum* | 2 | 12 | 2 | 17 | |
| *Stenonema pulchellum* | | | | 1 | |
| *Stenonema terminatum* | 11 | 16 | 3 | 21 | |
| Isonychiidae | | | | | |
| *Isonychia* spp. | 24 | 95 | 59 | 59 | |
| Tricorythidae | | | | | |
| *Tricorythodes* spp. | | | | 19 | |
| Plecoptera (Stoneflies) | | | | | |
| Perlidae | | | | | |
| *Acroneuria* spp. | 3 | 2 | 2 | 1 | |
| Pteronarcyidae | | | | | |
| *Pteronarcys* spp. | 1 | | 1 | | |
| Trichoptera (Caddisflies) | | | | | |
| Brachycentridae | | | | | |
| *Brachycentrus numerosus* | | 1 | | 1 | |
| Hydropsychidae | | | | | |
| *Cheumatopsyche* spp. | 7 | 4 | 2 | 25 | |
| *Hydropsyche bidens* | 663 | 529 | 237 | 259 | |
| *Hydropsyche orris* | 55 | 39 | 22 | 21 | |
| *Hydropsyche simulans* | 30 | 39 | 30 | 18 | |
| *Potamyia flava* | 148 | 42 | 14 | 25 | |
| **Total Organisms** | **1,081** | **1,069** | **491** | **593** | **49** |
| **No. Organisms/m²** | **10,810** | **10,690** | **4,910** | **5,930** | **490** |

*DAEC Discharge Canal

Samples were collected using Hester-Dendy artifical substrate samplers. Samplers were composed of five plates measuring approximately 0.01 m² per side per plate.

Table 24 (con't)

Benthic macroinvertebrates collected on Hester-Dendy artificial substrates from the Cedar River and the discharge canal in the vicinity of the Duane Arnold Energy Center, 9/3/97-10/16/97.

| Taxon | Lewis Access | U/S DAEC | D/S DAEC | ½ mi. Below Plant | Disc. Canal |
|---|---|---|---|---|---|
| Platyhelminthes | | | | | |
| Turbellaria | | | | | |
| Planariidae | | | | | |
| *Dugesia* sp. | | | 3 | | 5 |
| Annelida | | | | | |
| Oligochaeta (Naiadidae?) | | 11 | | 4 | |
| Hirudinea | | | | | |
| Pharyngodellida | | | | | |
| Erpobdellidae | | | | | 1 |
| Mollusca | | | | | |
| Gastropoda | | | | | |
| Physidae | | | | | |
| *Physa* sp. | | | | | 1 |
| Arthropoda | | | | | |
| Crustacea | | | | | |
| Amphipoda | | | | | |
| Talitridae | | | | | |
| *Hyalella azteca* | | | | | 1 |
| Insecta | | | | | |
| Coleoptera (Beetles) | | | | | |
| Elmidae | | | | | |
| *Stenelmis* sp. | | | 1 | | |
| Diptera | | | | | |
| Chironomidae | | 156 | 105 | 314 | 191 |
| Simuliidae | | | | | |
| *Simulium* spp. | | 4 | 4 | 5 | |
| Empididae | | | | | |
| *Hemerodromia* spp. | | 8 | 1 | 9 | |
| Ephemeroptera (Mayflies) | | | | | |
| Baetidae | | | | | |
| *Baetis flavistriga* | | 1 | | | |
| Heptageniidae | | | | | |
| *Heptagenia diabasia* | | 1 | | | |
| *Heptagenia pulla* | | 35 | 10 | 19 | |
| *Stenonema integrum* | | 8 | 2 | 10 | |
| *Stenonema pulchellum* | | | | 7 | |
| *Stenonema terminatum* | | 119 | 89 | 101 | |
| Ephemeridae | | | | | |
| *Hexagenia* sp. | | | | | 1 |
| Isonychiidae | | | | | |
| *Isonychia* spp. | | 9 | 2 | 6 | |
| Tricorythidae | | | | | |
| *Tricorythodes* spp. | | | | 1 | |
| Odonata (Zygoptera) | | | | | |
| Coenagrionidae | | | | | |
| *Argia* spp. | | | | | 9 |
| *Enallagma* spp. | | | | | 2 |
| Plecoptera | | | | | |
| Perlidae | | | | | |
| *Acroneuria* sp. | | | | 1 | |

Table 24 (con't)

| Taxon | Lewis Access | U/S DAEC | D/S DAEC | ½ mi. Below plant | Disc. Canal |
|---|---|---|---|---|---|
| Perlodidae | | | | | |
| *Isoperla nana* | | | 4 | | |
| *Isoperla* spp. (small) | | | | 2 | |
| Taeniopterygidae | | | | | |
| *Taeniopteryx* spp. | | 1 | 1 | 1 | |
| Trichoptera (Caddisflies) | | | | | |
| Brachycentridae | | | | | |
| *Brachycentrus numerosus* | | | | 1 | |
| Hydropsychidae | | | | | |
| *Ceratopsyche bronta* | | | | 1 | |
| *Ceratopsyche morosa (bifida)* | | 1 | | 1 | |
| *Cheumatopsyche* spp. | | 4 | 5 | 8 | |
| *Hydropsyche bidens* | | 627 | 253 | 604 | |
| *Hydropsyche orris* | | 31 | 29 | 56 | |
| *Hydropsyche simulans* | | 46 | 12 | 43 | |
| *Potamyia flava* | | 194 | 197 | 288 | |
| Leptoceridae | | | | | |
| *Nectopsyche* spp. | | | | 1 | |
| **Total Organisms** | - | 1,256 | 718 | 1483 | 211 |
| **No. Organisms/m$^2$** | - | 12,560 | 7,180 | 14,830 | 2,110 |

**No substrates were recovered from this site

Samples were collected using Hester-Dendy artifical substrate samplers. Samplers were composed of five plates measuring approximately 0.01 m$^2$ per side per plate.

Table 25

Daily Numbers of Fish Impinged at the Duane Arnold Energy Center
January - December 1997

| Day of the Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 0 | 13 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 10 | 3 |
| 2 | 15 | 15 | 11 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 8 | 1 |
| 3 | 0 | 5 | 10 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 |
| 4 | 3 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 5 | 2 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 4 |
| 6 | 0 | 0 | 1 | * | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 3 |
| 7 | 10 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 |
| 8 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 5 |
| 9 | 1 | 1 | 2 | 0 | 0 | * | 0 | 0 | 0 | 0 | 1 | 0 |
| 10 | 0 | 3 | 12 | 0 | 0 | * | 0 | 0 | 0 | 0 | 0 | 2 |
| 11 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 12 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 13 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 2 | 4 |
| 14 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | * | 3 | 2 |
| 15 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 1 | 0 | * | 0 | 2 |
| 16 | 1 | 0 | 1 | 3 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 18 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 2 |
| 19 | 0 | 16 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 1 |
| 20 | 0 | 5 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| 21 | 0 | 11 | 3 | * | 2 | 0 | 0 | 1 | 0 | 1 | 7 | 3 |
| 22 | 17 | 11 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 |
| 23 | 4 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| 24 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 6 | 18 | 2 | 1 |
| 25 | 1 | 10 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 4 | 1 |
| 26 | 0 | 22 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 |
| 27 | 0 | 4 | 1 | 0 | 1 | 0 | - | 0 | 0 | 16 | 1 | 2 |
| 28 | 0 | 14 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 3 | 2 |
| 29 | 0 | - | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 2 |
| 30 | 0 | - | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 4 | 0 | 0 |
| 31 | 0 | - | 0 | - | 0 | - | 0 | 0 | - | 0 | - | 2 |
| Total | 66 | 130 | 82 | 13 | 10 | 10 | 7 | 3 | 7 | 62 | 79 | 64 |

Total Annual 533

*No data

Table 26

Comparison of Average Values for Several Parameters at Upstream, Downstream and Discharge Canal Locations at the Duane Arnold Energy Center During Periods of Station Operation-1997

| Parameters | Upstream (Station 2) | Discharge Canal (Station 5) | Downstream (Station 4) |
|---|---|---|---|
| Temperature (°C) | 11.0 | 15.1 | 11.3 (102%) |
| Dissolved Solids (mg/L) | 283 | 1,034 | 308 (109%) |
| Total Hardness (mg/L) | 249 | 703 | 270 (108%) |
| Total Phosphate (mg/L) | 0.3 | 1.29 | 0.31 (103%) |
| Nitrate (mg/L as N) | 5.0 | 9.6 | 5.2 (104%) |
| Iron (mg/L) | 1.89 | 2.8 | 1.88 (99%) |

*Percent of upstream level ()

Table 27

Comparison of Average Yearly Values for Several Parameters in the Cedar River Upstream of the Duane Arnold Energy Center*
1972-1997

| Year | Mean flow** (cfs) | Turbidiity (NTU) | Total $PO_4$ (mg/L) | Ammonia (mg/L-N) | Nitrate (mg/L-N) | BOD (mg/L) | Total Hardness (mg/L) |
|---|---|---|---|---|---|---|---|
| 1972 | 4,418 | 22 | 1.10 | 0.56 | 0.23 | 5.7 | 253 |
| 1973 | 7,900 | 28 | 0.84 | 0.36 | 1.5 | 4.0 | 250 |
| 1974 | 5,580 | 29 | 2.10 | 0.17 | 4.2 | 4.7 | 266 |
| 1975 | 4,206 | 58 | 1.08 | 0.33 | 2.8 | 6.5 | 251 |
| 1976 | 2,082 | 41 | 0.25 | 0.25 | 2.8 | 7.3 | 233 |
| 1977 | 1,393 | 15 | 0.33 | 0.52 | 2.9 | 6.5 | 243 |
| 1978 | 3,709 | 23 | 0.26 | 0.22 | 4.4 | 3.3 | 261 |
| 1979 | 7,041 | 26 | 0.29 | 0.12 | 6.6 | 2.5 | 272 |
| 1980 | 4,523 | 40 | 0.34 | 0.19 | 5.4 | 4.3 | 238 |
| 1981 | 3,610 | 33 | 0.77 | 0.24 | 6.0 | 6.5 | 279 |
| 1982 | 7,252 | 43 | 0.56 | 0.23 | 8.0 | 5.1 | 274 |
| 1983 | 8,912 | 22 | 0.25 | 0.10 | 8.6 | 3.3 | 259 |
| 1984 | 7,325 | 40 | 0.32 | 0.10 | 5.9 | 3.9 | 264 |
| 1985 | 3,250 | 30 | 0.31 | 0.11 | 4.8 | 6.7 | 245 |
| 1986 | 6,475 | 33 | 0.26 | 0.10 | 6.8 | 3.7 | 285 |
| 1987 | 2,625 | 32 | 0.24 | 0.06 | 5.6 | 5.8 | 269 |
| 1988 | 1,546 | 28 | 0.30 | <0.16 | 2.8 | 9.6 | 246 |
| 1989 | 947 | 24 | 0.37 | <0.30 | 1.5 | 10.3 | 224 |
| 1990 | 5,061 | 33 | 0.29 | <0.20 | 7.3 | 4.8 | 283 |
| 1991 | 8,085 | 65 | 0.38 | <0.20 | 7.9 | 4.3 | 268 |
| 1992 | 5,717 | 49 | 0.31 | <0.16 | 6.4 | 5.5 | 261 |
| 1993 | 15,900 | 44 | 0.27 | <0.16 | 6.2 | 2.3 | 276 |
| 1994 | 4,701 | 34 | 0.28 | <0.22 | 5.1 | 5.3 | 269 |
| 1995 | 4,384 | 31 | 0.21 | <0.17 | 5.5 | 4.0 | 275 |
| 1996 | 3,200 | 34 | 0.29 | <0.21 | 4.7 | 7.0 | 254 |
| 1997 | 4,996 | 38 | 0.30 | <0.24 | 5.1 | 5.7 | 248 |

*Data from Lewis Access location (Station 1)

**Data from U.S. Geological Survey Cedar Rapids gauging station

Table 28

Summary of Relative Loading Values (Average Annual Concentration x Cumulative Runoff) for Several Parameters in the Cedar River Upstream of the Duane Arnold Energy Center 1972-1997

| Year | Mean flow** (cfs) | Cumulative** Runoff (in) | Turbidity (mg/L) | Total PO4 (mg/LO | Ammonia (mg/L-N) | Nitrate (mg/L-N) | BOD (mg/L) |
|---|---|---|---|---|---|---|---|
| 1972 | 4,418 | 9.24 | 203 | 10.2 | 5.2 | 2 | 53 |
| 1973 | 7,900 | 16.48 | 461 | 13.8 | 5.9 | 25 | 66 |
| 1974 | 5,580 | 11.64 | 338 | 24.4 | 5.0 | 49 | 55 |
| 1975 | 4,206 | 8.77 | 509 | 9.5 | 2.9 | 25 | 57 |
| 1976 | 2,082 | 4.35 | 178 | 1.1 | 1.1 | 12 | 32 |
| 1977 | 1,393 | 2.91 | 44 | 1.0 | 1.5 | 8 | 19 |
| 1978 | 3,709 | 7.74 | 178 | 2.0 | 1.7 | 34 | 26 |
| 1979 | 7,041 | 14.79 | 385 | 4.3 | 1.8 | 98 | 37 |
| 1980 | 4,523 | 9.45 | 378 | 3.2 | 1.8 | 51 | 41 |
| 1981 | 3,610 | 7.53 | 248 | 5.8 | 1.8 | 45 | 49 |
| 1982 | 7,252 | 15.13 | 651 | 8.5 | 3.5 | 121 | 77 |
| 1983 | 8,912 | 18.00 | 396 | 4.5 | 1.8 | 155 | 59 |
| 1984 | 7,325 | 15.22 | 609 | 4.9 | 1.5 | 90 | 59 |
| 1985 | 3,250 | 6.80 | 204 | 2.1 | 0.8 | 33 | 46 |
| 1986 | 6,375 | 13.11 | 433 | 3.4 | 1.3 | 89 | 49 |
| 1987 | 2,625 | 4.85 | 155 | 1.2 | 0.3 | 27 | 28 |
| 1988 | 1,546 | 2.85 | 80 | 0.9 | <0.4 | 8 | 27 |
| 1989 | 947 | 1.84 | 44 | 0.7 | 0.6 | 3 | 19 |
| 1990 | 5,061 | 9.34 | 308 | 2.7 | 1.9 | 68 | 45 |
| 1991 | 8,085 | 17.15 | 1115 | 6.5 | 3.4 | 135 | 74 |
| 1992 | 5,717 | 10.92 | 535 | 3.4 | 1.7 | 70 | 61 |
| 1993 | 15,900 | 32.39 | 1425 | 8.8 | 5.2 | 201 | 74 |
| 1994 | 4,701 | 10.45 | 355 | 2.9 | 2.3 | 53 | 55 |
| 1995 | 4,384 | 9.23 | 286 | 1.9 | 1.6 | 51 | 37 |
| 1996 | 3,200 | 6.67 | 227 | 1.9 | 1.4 | 31 | 47 |
| 1997 | 4,996 | 10.44 | 397 | 3.13 | 2.5 | 53 | 60 |

*Data from Lewis Access location (Station 1)

**Data from U.S. Geological Survey Cedar Rapids gauging station

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